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Monitoring Chlorpyrifos & Diazinon in Impaired Surface Waters of the Lower Salinas Region: Status Report No. 1

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Preface

This document will eventually be the final report of a project involving the monitoring of chlorpyrifos and diazinon in impaired surface waters of the lower Salinas region, Monterey County, California. This version is limited to a status report including the project background, aims and general methodology, previous work and a description of the study area.

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1 Background

A number of water bodies in the region surrounding Monterey Bay are listed as impaired due to 'pesticides' under Section 303(d) of the Clean Water Act. TMDLs must be developed for these water bodies. As explained below, the proposed work focuses on two currently applied pesticides: chlorpyrifos and diazinon.

Data are available in the region on the timing and location of pesticide application; on concentrations observed downstream in water, sediment, and tissue; and on the toxicity of aquatic organisms due to pesticides (Hunt et al., 1999). But a thorough analysis of the linkage between application data and later occurrence of pesticides in waterways is lacking. In particular, the spatial and temporal dynamics of pesticide transport in the region are poorly understood.

Of the currently used pesticides, chlorpyrifos and diazinon have been identified as being responsible for toxicity of crustaceans in a number of stream water samples, and are present in biologically effective quantities in sediments and tissues. Their concentration in streams exceeds levels that are known to impact the life cycles of higher organisms such as the federally endangered steelhead trout. 59 742 kg of diazinon and 42 408 kg of chlorpyrifos were applied in hydrologic unit 309 (Salinas Valley) in 1999, and concentrations of above 1 μg/L (in water) and 1 μg/kg (sediment) have been measured in waterways. Transport and transformation between the two appears to be highly dependent on intermittent peak stream flow, and originates from geographically disparate sources.

2 Aims & general methodology

This study aims to clarify the links between application of chlorpyrifos and diazinon and their appearance in 303(d)-listed water bodies by monitoring the movement of these chemicals in listed water bodies, and the mechanisms by which they are moved.

The following questions will be answered:

- Are concentrations of chlorpyrifos and diazinon above levels that limit aquatic ecosystem health?

- What is the variability of *in situ* sediment chlorpyrifos and diazinon concentration and load during ambient non-winter conditions?
- Is it possible to measure loads of chlorpyrifos and diazinon that explain this variability?
- Are loads significant during ambient non-winter conditions?
- Are loads significant during winter events?
- Is there evidence that urban loads are significant?
- Is there evidence that agricultural loads are significant?
- Are the data consistent with published half-lives?
- Is aqueous transport of chlorpyrifos and diazinon significant?
- Is adsorbed transport of chlorpyrifos and diazinon significant?
- Is there a relationship between total suspended solids and transport of chlorpyrifos and diazinon?

Samples will be taken both within listed water bodies, their sediments, and the flows into these water bodies. A dual focus on both ambient and event-based sampling will be used. Ambient sampling will be done to establish baseline spatial patterns and potential 'hot spots'. Event-based sampling will then be done both in response to summer irrigation and winter rainfall events in an attempt to identify the most important dynamics of chlorpyrifos and diazinon delivery to receiving waters. This will include analysis of flow and sediment concentration covariates.

We anticipate that there will be significant spatial, temporal, and matrix variation in chlorpyrifos and diazinon concentrations and loads. Spatial variation is expected due to different application, transport regimes, and degradation regimes in the seven quite different listed water bodies. Temporal variation is expected for the same reasons, and also because of the differing flow regimes of in-growing-season (summer) and out-of-growing-season (winter) flows. We expect to find a relationship between storm hydrograph peaks and pesticide levels in situations when storms overlap, or almost overlap with the growing season. Finally, we expect matrix variation due to other substances present in samples. In particular, we expect a correlation between pesticide concentrations and fine sediment concentration. If this is the case, there are significant implications for the expectation of pollutants adsorbed to any loads of fine sediment observed in the region.

3 Previous Work

Previous studies of pesticides in the 303(d) listed water bodies in the Monterey Bay area include:

- State Mussel Watch Program (SMW): www.swrcb.ca.gov/programs/smw
    - 3 reports: State Water Resources Control Board (SWRCB), 1994, 1996, 2000
- Toxic Substances Monitoring Program (TSM): www.swrcb.ca.gov/programs/smw
    - 3 reports: SWRCB, 1993, 1995a, 1995b
- Chemical and Biological Measures of Sediment Quality in the Central Coast Region (SWRCB et al., 1998): a.k.a. Bay Protection and Toxic Cleanup Program (BPTC)
- Central Coast Ambient Monitoring Program (CCAMP): http://www.ccamp.org/

The data from SMP, TSM and CCAMP is available online from CCAMP. Databases for SMP and TSM are also available at: www.swrcb.ca.gov/programs/smw. Study data available for each site we will monitor can be found in Table 1.

Little information on chlorpyrifos and diazinon emerged from these studies. Data from the SMW and TSM are strictly from tissue samples. CCAMP and BPTC have addressed chlorpyrifos and diazinon in sediments to a limited extent. There are no studies that we have found to date that address the spatial and temporal variation in loads of these pesticides. We have found no water quality data available on our specific sample sites from federal sources (e.g. USGS), however, there is data for other sites on the Salinas River.

Table 1. Studies at sites monitored for chlorpyrifos or diazinon.

Site	Study	C or D monitored	C or D found
Salinas River	TSM, CCAMP	Y	N
Salinas Lagoon	SMW, TSM, BPTC, CCAMP	Y	Y
Blanco Drain	SMW, TSM	Y	Y
Reclamation Ditch	SMW, TSM, CCAMP	Y	Y
Old Salinas River	SMW, TSM, CCAMP	Y	Y
Moss Landing Harbor	SMW, TSM, BPTC, CCAMP	Y	Y
Espinosa Slough	SMW, TSM, BPTC, CCAMP	Y	Y

4 Study Area

4.1 Study Area Description

The study area for this project is located in the lower Salinas Valley of Monterey County, California (Fig. 1). A total of nine study sites (Table 2) are located within a system of interconnected rivers, creeks, ditches, sloughs, and lagoons draining into the Monterey Bay National Marine Sanctuary via the Old Salinas River through Moss Landing Harbor and the Salinas River flowing directly to the Pacific Ocean.

All of the nine locations are 303(d) listed water bodies for pesticides and are loosely classified as either 'flux' or 'receiving' sites (Table 1). 'Flux' sites are located on waterways, which generally have continuous flow and are therefore capable of transporting pollutants such as chlorpyrifos and diazinon, either dissolved in the water column or adhered to suspended sediment particles. 'Receiving' sites are located in settling areas, where water velocities are typically lower and much of the suspended sediment has settled out the water column into the benthos.

Table 2. Pesticide Monitoring Sites

Site #	Waterway	Location	Site Code	Type
1	Salinas River	Davis Rd.	SAL-DAV	Flux
2	Salinas Lagoon	Del Monte Rd.	SAL-LAG	Receiving
3	Blanco Drain	Cooper Rd.	BLA-COO	Flux
4	Blanco Drain	Pump-out station	BLA-PUM	Receiving
5	Reclamation Ditch	San Jon Rd.	REC-JON	Flux
6	Old Salinas River	Potrero Rd.	OSR-POT	Flux
7	Moss Landing Harbor	Sandholdt Rd.	MOS-SAN	Receiving
8	Espinosa Slough	Rogers Rd.	ESP-ROG	Flux
9	Espinosa Slough	Mid-lake	ESP-LAK	Receiving

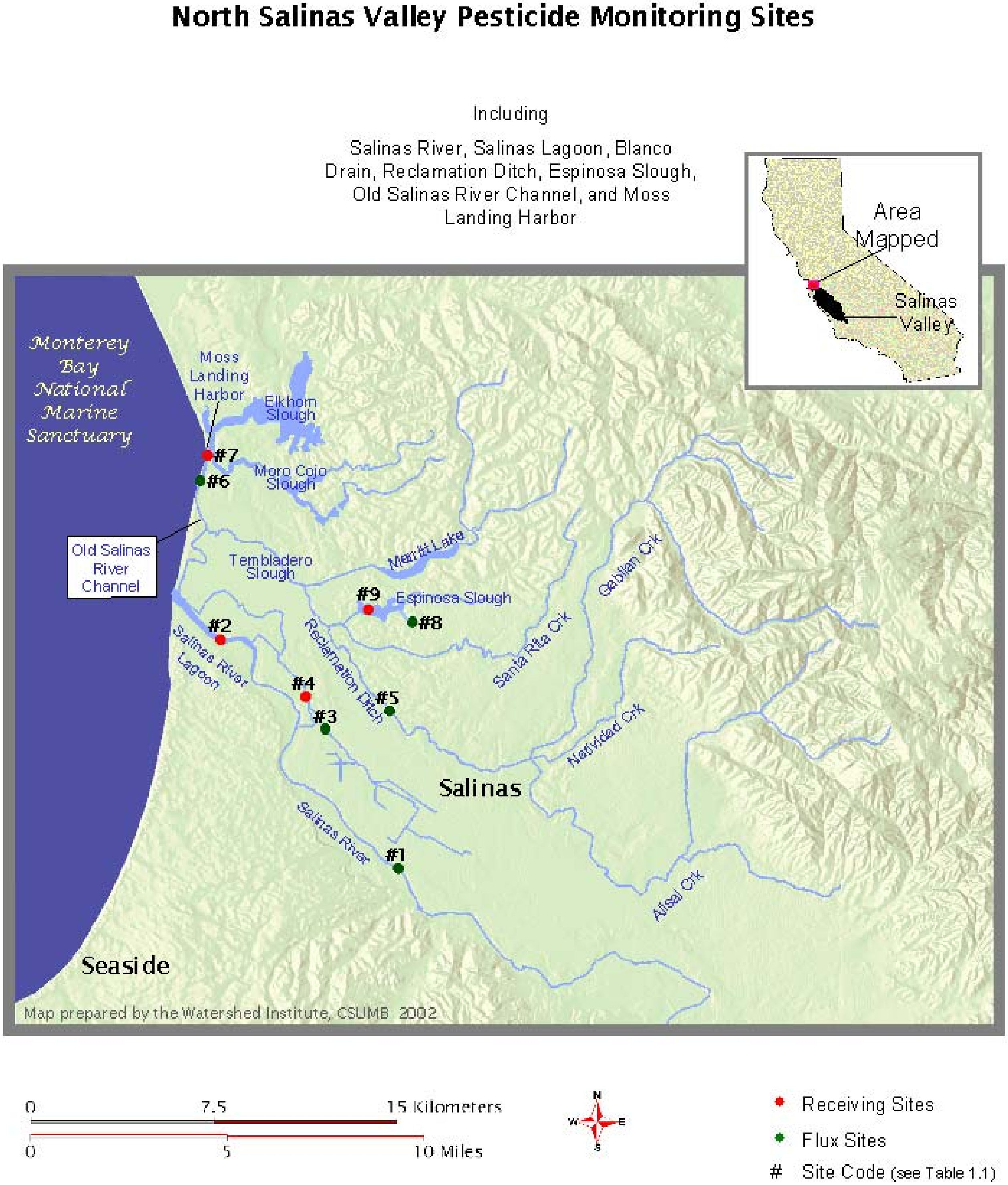

Figure 1. Map of North Salinas Valley showing study area and pesticide monitoring sites.

4.2 Site Descriptions

Site #1

Site 1 (Fig. 2) is located on a perennial reach of the Salinas River at the Davis Road crossing, approximately 14 km upstream from Site #2. Site 2 is an ideal location to measure the majority of loads delivered by the Salinas River to receiving waters such as the Salinas Lagoon and the Pacific Ocean. Not only is this location a major zone of transport of pollutants, but it also provides *in situ* habitat for species such as the federally threatened steelhead, other native fish of the Salinas River, waterfowl, and other aquatic organisms.

The low flow channel is approximately 5 m wide with sand as the dominant substrate. The main channel ranges approximately 100-200 m wide. Riparian vegetation is abundant and the surrounding land use is primarily row-crop agriculture.

Figure 2. Site #1-Salinas River looking upstream from Davis Rd. (Photo: Don Kozlowski)

Site #2

Site 2 (Fig.3) is located on the Salinas Lagoon at Del Monte Road, less than 3 km upstream from the mouth with Pacific Ocean. This location receives all the flow and loads of pollutants from the Salinas River as well as some from Site #4 (Blanco Drain). The Salinas Lagoon supports several unique threatened and endangered species including: Menzies Wallflower, Slender-Flowered Gilia, Smith's Blue Butterfly and its host-Coastal Buckwheat, snowy plover, black legless lizard, dune beetle, and south-central coast Steelhead.

The channel is much wider than at Site 1, and the substrate has a higher percentage of silt and clay. Riparian vegetation is less abundant than at Site 1, and the adjacent land use is predominantly row-crop agriculture with some residential and recreational land use.

During winter storm events, flow from the Salinas River will fill this lagoon until it breaches or is breached by the Monterey County Water Resources Agency, sending pollutants directly to the ocean. Otherwise, flow is directed from the lagoon down the Old Salinas River Channel to Moss Landing Harbor via the Potrero tide gates.

Figure 3. Site #2-Salinas Lagoon looking upstream from Del Monte Rd. (Photo: Don Kozlowski)

Site #3

Site 3 (Fig. 4) is found on the channelized system known as Blanco Drain, one of the more polluted areas according to data from the State Mussel Watch Program. It is located at the Cooper Road crossing, approximately 1.5 km upstream of the receiving area of the Blanco Drain pump station (Site #4). This makes it an ideal site to monitor for pesticide flux contributed by the adjacent land use, row-crop agriculture. Historically a freshwater wetland, the system was channelized to drain storm and agricultural runoff. The drainage originates just south of the city of Salinas and flows north approximately parallel to the Salinas River. Blanco Drain lacks riparian vegetation and is comprised of a predominantly silt/clay substrate.

Figure 4. Site #3-Blanco Drain looking upstream from Cooper Rd. (Photo: Don Kozlowski)

Site #4

Site 4 (Fig. 5) is located on the Blanco Drain, approximately 1.5 km downstream of Site 3, and immediately upstream from the pump-out station. Blanco Drain flows to the pump-out station where water is impounded (left side of Fig. 5) and then pumped into the Salinas River (less than 0.5 km to the west) via a connecting channel (right side of Fig. 5). This monitoring location serves as an area of low water flow where sediments settle. The adjacent land use is row-crop agriculture.

Figure 5. Site #4-Blanco Drain looking upstream from pump-out station to the Salinas River. (Photo: Don Kozlowski)

Site #5

Site 5 (Fig. 6) is located on the Reclamation Ditch at San Jon Road. It is approximately 12 km upstream from the confluence of Tembladero Slough and the Old Salinas River channel and approximately 5 km downstream from the city of Salinas. The Reclamation Ditch originates near Carr Lake in Salinas and captures the drainages of Gabilan, Natividad, and Alisal creeks. The Reclamation Ditch was constructed in 1917 to route waters from Salinas and nearby agricultural fields into Tembladero Slough and finally into Moss Landing Harbor through the Potrero tide gates. Site 5 therefore serves as a good 'flux' site for monitoring pesticides from the city and some agriculture on the way to those gates. The Ditch is channelized, lacks riparian vegetation, and the primary substrate is silt/clay. Adjacent land use at this site is row-crop agriculture. This site is also the past and future location of a United States Geological Survey gauging station.

Figure 6. Site #5-Reclamation Ditch looking upstream from San Jon Rd. (Photo: Don Kozlowski)

Site #6

Site 6 (Fig. 7) is located on the Old Salinas River channel at the Potrero Road, approximately 14 km downstream of Site 5. This location serves as a ‘flux’ site for the study as flow from the channel is directed through the Potrero tide gates. However, the gates tend to slow the flow enough to widen the channel, allowing sediments to drop to the benthos. In this respect, it is also a ‘receiving’ site. This site will have pollutant contributions from all other upstream sites. The channel has a predominantly silt/clay substrate and lacks significant riparian vegetation. The adjacent land use is mainly row-crop agriculture with some recreational land use.

Figure 7. Site #6-Old Salinas River looking upstream from Potrero Rd. (Photo: Don Kozlowski)

Site #7

Site 7 (Fig. 8) is located in Moss Landing Harbor at the Sandholdt Road crossing, approximately 1 km downstream of Site 6. This site is the 'receiving' location for flow from the Old Salinas River channel and Tembladero Slough. Being connected to the ocean, it is significantly influenced by the tide. Contribution of pesticide pollution from the Old Salinas River Channel to Elkhorn Slough is largely dependant upon flows past this site and tidal dynamics, in this respect making it a 'flux' site, also. The channel is broad and lacks riparian vegetation, but has abundant tidal marsh vegetation. The primary substrate is silt/clay with some riprap.

Figure 8. Site #7-Moss Landing Harbor looking downstream from Potrero Rd. (Photo: Joel Casagrande)

Site #8

Site 8 (Fig. 9), a 'flux' site, is located on an upstream tributary to Espinosa Lake at the Rodgers Road crossing. The drainage originates northeast of the city of Salinas, flows into Espinosa Lake, and if necessary is pumped into the Reclamation Ditch for flood control. This channelized arm of Espinosa Slough is an agricultural ditch, approximately 1 to 2 m wide, and a major contributor of Espinosa Lake's water. The channel lacks riparian vegetation and the dominant substrate is silt/clay. Adjacent land use is row-crop agriculture. There is significant contribution of water flow from upstream greenhouses.

Figure 9. Site #8-Espinosa Slough looking upstream from Rodgers Rd. (Photo: Don Kozlowski)

Site #9

Site 9 (Fig. 10) is located in the middle of Espinosa Lake, approximately 2 km west of Site 8. This location will serve as a 'receiving' site for the study and will be accessed via kayak. The lake has limited riparian vegetation and the adjacent land uses are row-crop agriculture, grazing, and residential. In the event of flooding, Espinosa lake is drained by a pump sending water into the Reclamation Ditch.

Figure 10. Site #9-Espinosa Lake looking east. (Photo: Don Kozlowski)

5 References

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Prepared by Don Kozlowski and Fred Watson
Schedule for Diazinon and Chlorpyrifos Monitoring in Impaired Surface Waters of the Lower Salinas Region
Funded by the State Department of Pesticide Regulation and the State Water Resource Control Board

		Jul	Aug	Sep"a"	Sep"b"	Oct	Nov & Dec'02, Jan, Feb, Mar'03									Apr	May	Jun	Jul	Aug	Sep	Oct
		Summer '02 Ambient Monitoring					Storm A			Storm B			Storm C			Summer '03 Ambient Monitoring						
Site #	**Site Code**						**Pre-**	**Peak**	**Post-**	**Pre-**	**Peak**	**Post-**	**Pre-**	**Peak**	**Post-**							
1	**SAL-DAV**	X	O	O	O	O	O bdg	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
2	**SAL-MON**	O	X	O	O	O	O		O wdg	O		O	O		O	O	O	O	O	O	O	O
3	**BLA-COO**	O	O	X	O	O	O	O	O	O wdg	O	O	O	O	O	O	O	O	O	O	O	O
4	**BLA-PUM**	O	O	O	X	O	O		O	O		O bdg	O		O	O	O	O	O	O	O	O
5	**REC-JON**	O	O	O	O	X	O	O	O	O	O	O	O wdg	O	O	O	O	O	O	O	O	O
6	**OLS-POT**	O	O	O	O	O	O	O	O	O	O	O	O	O	O bdg	X	O	O	O	O	O	O
7	**MOS-SAN**	O	O	O	O	O	O		O	O		O	O		O	O	X	O	O	O bdg	O	O
8	**EP1-ROG**	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	X	O	O	O wdg	O
9	**EPL-EPL**	O	O	O	O	O	O		O	O		O	O		O	O	O	O	X	O	O	O bdg

O = Normal sampling scheme (Water, Benthic and Suspended Sediment samples for ELISA analysis)
X = Normal sampling scheme with additional Water and Benthic duplicates plus Water and Benthic sampling for GCMS analysis
wdg = water duplicate & water GCMS
bdg = benthic duplicate & benthicGCMS

Notes: QA/QC samples are highlighted in blue. This schedule is tentative. Circumstances such as staff scheduling/availability and weather conditions may necessitate changes.